Supply and Demand for Terrorism Insurance: Lessons from Germany

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Abstract
In our article we consider insurance as a means of allocating terrorism risk. Terrorism poses a significant challenge for insurers worldwide. In terms of possible losses it fits into the same category as earthquakes and hurricanes. Yet as a result of the uncertainty surrounding these risks private markets face significant difficulties in providing insurance for it. In the insurance industry costly risk bearing can explain the supply of capacity risks. Corporate risk management theory provides reasons why transaction costs can motivate firms to purchase insurance. In the context of these tightly connected theories we derive models for both the supply of terrorism reinsurance and the demand for terrorism insurance. Using two datasets from the German terrorism insurer we estimate models on how corporations in Germany employ government sponsored insurance to manage their terrorism risk and on the factors that determine the supply for private market terrorism reinsurance

Keywords: Terrorism; Insurance; Risk Allocation; Regulation

JEL Classification: G22, G32, D61

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INTRODUCTION

The attacks of September 11th 2001 have not only claimed the lives of over 3.000 citizens of more than 80 countries. The terrorist aggressions against New York and Washington have placed terrorism among other catastrophe risks like hurricane and earthquake risk. It has also resulted in one of the most expensive insured losses in history. The inflation adjusted insured damage of September 11th, 2001 is only surpassed by the losses from the hurricanes Katrina (2005) and Andrew (1992).[1] The dangers connected with terrorism have also caused significant changes in the interaction between citizens and their governments. Civil liberties have been reduced in an effort to cope with this special risk. Yet the threat is still present. The terrorist attacks in Madrid (March 11th, 2004) and London (July 7th, 2005) provide evidence that worldwide efforts to fight terrorism have not eliminated this peril. As a result of widespread exclusion of terrorism risk from standard policies governments in the United States, France and Germany have intervened in insurance market. Although the interventions are not identically, the governments assume an active role in bearing terrorism risk.

Our research is focussed on the following questions. What drives the demand for terrorism insurance Germany and which factors determine the supply of terrorism reinsurance?[2] By investigating these two questions, which have so far not been answered in a satisfactory manner in the literature we provide insights into the allocation of this "new" risk through the insurance market. These insights might allow improving the present regulation of terrorism risk allocation in Germany and the United States. While various aspects of the corporate demand for insurance have been analyzed, the supply of terrorism insurance has so far not been studied.[3] Yet, as the allocation of terrorism risk is highly regulated, i.e. through the American Terrorism Risk Insurance Act, it is of great importance to understand what determines comparative advantages in bearing terrorism risk. Our article establishes new evidence of these advantages and might thereby help to improve regulation. We inquire into the matter using two datasets from the German government sponsored insurer Extremus. The dataset contains information on all contracts sold through Extremus in the years 2003 and 2004. On the supply side the dataset includes information on the supply of terrorism reinsurance for the year 2004/5. According to OECD (OECD (2003)) Germany is the world's

[1] All losses are adjusted for inflation. See Swiss Re (2006) for details.
[2] Borch (1962) provides the theory behind these questions in a complete market model.
[3] The next section provides a detailed overview. Gron (1999) analyzes the demand for reinsurance for catastrophe risks. A of the demand for terrorism insurance was estimated by Wharton Risk Management and Decision Process Center (2005).

third largest non-life insurance market. In the year 2001 Germany's market share were 6.43 % of direct gross premiums. Only the United States (58.78 %) and Japan (7.27 %) had larger non-life insurance markets.

The paper is organized in six sections: in the next section we give a short overview on terrorism and insurance. Thereafter we discuss the reasons provided in the literature why risk is costly for both corporations and insurers. Consequently we present our dataset, adjust the hypotheses and estimate a model of the supply of terrorism insurance. Thereafter we present our dataset on the corporate demand for terrorism insurance in Germany, modify the hypotheses and estimate two regression models. Our article ends with a conclusion.

TERRORISM RISK AND INSURANCE

Since September 11th 2001 several authors have worked on various aspects of terrorism and insurance. Stempel (2002) gives a survey of the different insured claims in result of the attacks. Dixon et al. (2004) focus on the compensation of victims by government and charity. Doherty et al. (2003) analyses the recovery of the insurance market after the 2001 terrorism losses. Kunreuther et al. (2003b) bring forward the difficulties that surround terrorism risk from an insurance perspective. The authors point out that as a result of information problems[4] and dynamic uncertainty[5] the insurance industry will need additional safety loadings in order to provide coverage for this peril.[6] These loadings will increase the price for the transfer of terrorism risk even beyond the loadings necessary to insure against natural catastrophe risks. The institutional arrangements founded after the attacks in the United States, France and Germany to insure against terrorism are introduced by Michel-Kerjan et al. (2005).[7] The only study using some empirical data on terrorism demand was conduced by Wharton Risk Management and Decision Process Center (2005).[8] The small number of empirical studies of the government-sponsored schemes contrasts the macroeconomic importance of terrorism risk allocation. Hubbard et al. (2005) estimate the macroeconomic effects of federal participation in terrorism risk allocation: "Absent another major terrorist attack, GDP may be $ 53 billion

[4] Governments will always be better informed on terrorism risk than the insurance industry.
[5] Terrorists can substitute between targets. Different authors (Kunreuther et al. (2003a), Lakdawalla et al. (2005)) study market failures connected with independent security of agents.
[6] Froot (1999) provides an in-depth analysis of the pricing of catastrophe risks. His research shows that substantial loadings are necessary to obtain insurance for catastrophe risk.
[7] Using stock price data Brown et al. (2003) find no evidence that interest groups were able to benefit from the intervention of the American government on the terrorism insurance market.
[8] Their (Wharton Risk Management and Decision Process Center (2005)) study is based on a survey conducted by the insurance brokerage firm AON. They find evidence that companies not located in the West purchase more insurance, larger corporations demand lower degrees of coverage and that insurance demand differs between sectors.

(0.4 %) lower, household net worth may be $ 512 billion (0.9 %) lower, and roughly 326,000 (0.2 %) fewer jobs may be created."

In Germany the terrorism risk insurer Extremus was founded in 2002. Its capital is held by 16 insurance companies. Extremus offers excess of loss contracts for property and casualty risks with total insured values above € 25 millions that are located in Germany.[9] The maximum annual compensation is limited to € 1.5 billion per policyholder. In the years 2004 and 2005 the company used a quota-share reinsurance contract to cover the first layer of claims between € 0 and € 2 billions. The layer from € 2 billions up to € 10 billions is reinsured by the German government. Extremus uses a uniform pricing scale, which only reflects the total insured value and the maximum annual deductible.

In the following section we present reasons why risk can be costly for corporations and insurers.

CORPORATE RISK MANAGEMENT, INSURANCE DEMAND AND COSTLY RISK BEARING

Before we analyze both the supply and demand for terrorism insurance in Germany using two unique datasets from Extremus it is necessary to discuss the motivation for risk management in a corporate setting and to present empirical findings. The theoretical framework of the corporate demand for insurance is different from that of a risk averse individual. Firms cannot be genuinely risk averse. The motives for purchasing insurance in a corporate setting have been identified by Mayers et al. (1982), Stulz (1984), MacMinn (1987) and Froot et al. (1993). They include: efficient allocation of risks, real services like claims administration and assistance in assessing the effectiveness of loss prevention offered by insurance companies, optimization of tax burden and control of agency problems, regulation and compulsory insurance laws. Among others empirical studies were conducted by Mayers et al. (1990), Yamori (1999), Hoyt et al. (2000) and Gron (1999). Mayers et al. (1990) studied the demand for reinsurance by US insurers. While Yamori (1999) focused on the corporate demand for primary insurance in Japan in his study, Hoyt et al. (2000) investigated the corporate demand for primary insurance in the United States. Gron (1999) examined the demand for catastrophe reinsurance in the United States. Cole et al. (2006) looked at the demand for (international) reinsurance by primary insurers. The supply of earthquake insurance was studied by Kleffner et al. (1996).

[9] The deductible is 1 % of the total insured value.

Costly risk bearing: Stone (1973) identifies two types of risks. For some risks the number needed to obtain a joint distribution is rather small. These risks are "tightly distributed (highly predictable) on an individual basis". We will call them standard risks. On the other hand, capacity risks have high standard deviations and "would require massive numbers to reach a proper distribution". Terrorism can be considered to be of the second kind.[10] In contrast to standard risks, where underwriting an additional independent risk is likely to lower the ratio of standard deviation to expected value, insuring capacity risks might increase the volatility of an insurer's cash flow. In accordance with portfolio theory standard risks can be insured without a risk premium. Capacity risks, i.e. natural catastrophe risk or terrorism risk, are likely to increase cash flow volatility. As cash flow volatility is less costly for some insurers than for others, comparative advantages connected with risk bearing can exist. Efficient markets will allocate capacity risks according to comparative advantage.[11] In the next section we provide factors explaining the cost of risk for individual insurers.

Greater Efficiency in the allocation of risk among a company's stakeholders: Mayers et al. (1982) state that in a firm environment, where contracting is assumed to be costly, there are incentives to allocate risk to the claimholders that possess a competitive advantage in risk bearing. Since bond- and shareholders can easily profit from diversification, risk is less costly to them. Other stakeholders, such as employees and suppliers, cannot diversify away these risks and are therefore likely to charge a higher risk premium. The problem a corporation with limited liability faces is that the risk which can be allocated to stockholders and bondholders is limited because the contracts with both parties are written to include a put-option with an exercise price of 0. As insurers can benefit from diversification and therefore charge a lower risk premium, a company can gain from purchasing insurance.

Real Service Efficiencies: Buying an insurance contract incorporates more than a payment on behalf of the policyholder (premium) and the promise of the insurer to reimburse the policyholder on the condition that a specified event occurs. Insurance companies are experts in dealing with risks, loss prevention, loss control and claims management after a claim has occurred. Doherty et al. (1993) state that "the primary source of demand for insurance by widely held public companies is not as standard insurance textbooks assume, to transfer risk from the corporation's owners but rather to take advantage of insurance companies' efficiencies in providing risk-assessment, monitoring, and loss-settlement services." Since smaller companies have less expertise in risk management, loss control and

[10] Doherty (1983) provides a measure of capacity.
[11] Compare also Kleffner et al. (1996), pg. 658-660.

administration of claims, Mayers et al. (1982) argue that the expertise insurance companies possess provides incentives for small companies to buy insurance.

Taxes: A company facing a convex tax function can benefit from insurance as it helps to smooth its profits. The expected tax liabilities with insurance will be lower than without. Commonly used models show that in cases where companies are confronted with convex tax schedules and limited loss carry forwards insurance will help to optimize the tax payments of a corporation.

Insolvency Costs: Insolvency costs are reasons why companies purchase insurance. MacMinn (1987) shows how purchasing insurance can add to a company's value in the presence of bankruptcy costs. Although bankruptcy costs are certainly realistic, their presence alone does not necessarily provide sufficient motivation to buy terrorism insurance as „the increase in value is simply the present value of insolvency costs"[12]. This number also marks the upper limit to which a company could pay a loading on its insurance contract and still add value for its shareholders.

Agency Problems / Underinvestment: Myers (1977) demonstrates that under certain circumstances a company with risky debt in the capital structure, that is acting in the best interest of stockholders and is faced with a casualty loss, might decide not to replace a positive net present value project, because the profits accrue only to bondholders. Mayers et al. (1990) show that an insurance policy can help to control this incentive problem. The necessary condition for an insurance policy to create value is that the loading on the fair premium is smaller than the gains from controlling for the incentive problem.

Regulation and Compulsory insurance laws: Mayers et al. (1982) argue that regulation has an influence on a corporation's insurance purchases. Regulation can involve laws requiring corporations to purchase insurance (compulsory insurance), but it may also allow corporations in regulated markets with little competition to pass on the costs of insurance to its customers. Today corporate governance, debt covenants, disclosure rules and requirements of directors' and officers' insurance for underlying property and casualty covers might provide for additional motivation to select corporate insurance.

[12] MacMinn (1987), pg. 668.

SUPPLY OF TERRORISM INSURANCE: DATA, METHODOLOGY AND RESULTS

In the following paragraphs we investigate the factors driving the supply of terrorism reinsurance in Germany. While terrorism risk allocation in the United States is highly regulated the allocation of terrorism risk through reinsurance in Germany can be considered a market outcome. The allocation might provide insights into comparative advantages and allow for improving the regulation in the United States and elsewhere. Similar to Kleffner et al. (1996) we test if an insurer's supply of terrorism reinsurance is inversely related to the cost of risk bearing. As the discussion on this topic suggests the costs for bearing capacity risks will differ among insurance companies.

In accordance with the research conducted by Doherty et al. (2003) it can be expected that the legal form of an insurer has a significant influence on the supply of terrorism reinsurance. The owners of joint-stock companies can easily diversify their claims across various companies and industries. These companies are also able to recapitalize after a large (terrorism) loss. Mutual insurers cannot issue shares subsequent to a catastrophe. As insurance prices tend to increase as a result of a large loss mutual insurers might lack the necessary capital to sell insurance. Consequently they might not be able to profit from rising prices. We therefore expect *joint-stock companies* (JOINTSTOCK) to underwrite more terrorism reinsurance.

Mayers et al. (1982) mention insolvency costs as motivation to purchase corporate insurance. The research of Warner (1977) suggests that expected bankruptcy costs do not increase proportionally with firm size implying that larger firms will be less affected by them. Accordingly we hypothesize that larger corporations will have a competitive advantage to offer terrorism reinsurance. We measure the corporation's size as the *gross premium income* (PREMIUMINC) in 2003.

Borch (1962) demonstrates that absent transaction costs insurers will always cede all risks to a pool and underwrite some part of it proportional to their risk tolerance. In a perfect market context the relationship between purchasing insurance and supplying reinsurance is indeterminate. Allowing for transaction costs to diversify unsystematic risk it can be assumed that an insurer lacking terrorism capacity will be more likely to *insure assets with Extremus* (POLICYHOLDER).

The shares of Extremus are held by 16 insurance companies. Owning shares of Extremus implies a competitive advantage for bearing terrorism risk. It seems to be coherent to assume that these insurers will supply more terrorism reinsurance (SHAREHOLDER).

The reasoning presented shows that the company specific costs of terrorism risk bearing will be determined by *company size*, *legal form*, and if an insurer is a *policyholder* of Extremus or *holds equity* of the terrorism insurer. Table 1 summarizes the hypothesized effects.

Table 1: Hypothesized Effects

Dependent Variable			
MPL_SPLUS	=	$\frac{\text{maximum possible loss}}{\text{surplus}}$	
Independent Variable			**Hypothesized Sign**
log(PREMIUMINC)	=	Log(Gross Premium income in 2003)	+
SHAREHOLDER	=	1, if insurer is shareholder of Extremus, else 0	+
POLICYHOLDER	=	1, if insurer is customer of Extremus, else 0	-
JOINTSTOCK	=	1, if insurer is a joint-stock corporation, else 0	+

The hypotheses are tested using data on terrorism risk allocation in Germany. Information on maximum possible loss from underwriting terrorism reinsurance through Extremus is obtained from the reinsurance contract the company uses to allocate terrorism risk. Company specific information is obtained from the German supervisory authority. The data is aggregated according to information provided by Hoppenstedt. It is augmented with information on shareholder structure that is published by Extremus (2004). The figures on the company specific demand for terrorism insurance are obtained from the customer dataset of Extremus presented in the next section. The amount of terrorism risk a reinsurer assumes is measured as the ratio of the *possible maximum loss* from reinsuring Extremus to the *company's surplus* (MPL_SPLUS). To give the reader an idea of the relation between gross premium income and the possible maximum loss from its supply of reinsurance to Extremus we include information on this ratio (MPL_GP). The dataset reflects all property and casualty insurers that were supervised by the German regulators in 2003.[13] Table 2 presents the descriptive statistics

[13] We were able to match € 1 billion of possible terrorism claims.

Table 2: Descriptive Statistics

Variables	N	Mean	Std. Dev.	Minimum	Maximum
MPL_SPLUS	95	0.10	0.40	0	2.53
MPL_BP,	105	0.004	0.012	0	0.10
MPL_BP| MPL_BP>0	21	0.018	0.023	0.003	0.10
log(PREMIUMINC)	105	4.49	2.20	0	9.36

MPL_SPLUS= $\frac{\text{maximum possible loss}}{\text{surplus}}$, log(PREMIUMINC)= log of Gross Premium Income. Of 105 independent insurance groups 13 insurers are SHAREHOLDER of Extremus, 16 are POLICYHOLDER and 37 are JOINTSTOCK companies.

We estimate the equation using the dataset. As the depended variable is truncated at zero we apply a Tobit-Model.[14] The model estimated is:

$$\text{MPL\_SPLUS} = \beta_0 + \beta_1 \log(BPE) + \beta_2 SHAREHOLDER + \beta_3 POLICYHOLDER + \beta_4 JOINTSTOCK + \varepsilon$$

The results of the Tobit regression model are reported in Table 3[15]

Table 3: Tobit Estimation Model

Variable	MPL_SPLUS
log(PREMIUMINC)	0.614
	(3.00)**
SHAREHOLDER	0.303
	(0.68)
POLICYHOLDER	-0.996
	(2.43)*
JOINTSTOCK	0.280
	(0.83)
Constant	-4.407
	(3.45)**
Observations	95

t-Statistics in Brackets: * significant on 5 % Level; ** on 1 %-Level

Consistent with our hypothesis we find that the company specific costs of risk bearing determine the amount of terrorism reinsurance underwritten:

- larger insurers offer more terrorism reinsurance,
- shareholders of Extremus underwrite more terrorism risk,
- joint-stock insurers accept more terrorism risk and
- insurers purchasing terrorism coverage supply less terrorism reinsurance.

The research shows that insurer's attitudes towards bearing terrorism risk display strong similarities to other capacity risks, namely earthquake risk. We can state that although there

[14] The variable MPL_SPLUS cannot take on negative values. See Greene (2003), pg. 764 for details on truncated variables.

[15] Further information on the Tobit model can found: Greene (2003), pg. 765. Our model is highly significant ($X^2(4) = -50.16$).

are differences between terrorism and natural catastrophe risk the insurance market seems allocate both types of risk according to comparative advantage. We learn how much capacity insurers allocate for terrorism risk (at given premiums) if participation is voluntary. The average reinsurance capacity for terrorism risk of the participating insurers was the equivalent of 0.023 % of gross premium income in the year 2004. This number is comparably smaller than the deductibles individual insurers have to bear according to the Terrorism Reinsurance Act.[16] In the United States deductibles are between 7 % of the gross premium income in property and casualty insurance in 2003 and will rise to 20 % in the year 2007. Our model displays that relative risk bearing capability seems to increase with size. This means smaller insurers might be confronted with greater difficulties bearing the deductibles. The theory on efficient risk allocation requires that unsystematic risks be reduced through diversification. Other risks are to be borne according to comparative advantage. Given that larger insurers might have a comparative advantage for bearing terrorism risk, a deductible proportional to premium income might violate the principle of efficient risk allocation.

We will now investigate the factors driving the demand for terrorism insurance in Germany through Extremus.

CORPORATE INSURANCE DEMAND: THE CASE OF TERRORISM INSURANCE IN GERMANY

Terrorism risk differs from other catastrophe risks due to dynamic uncertainty and information problems. These factors will force private insurers to demand even higher surcharges than would be necessary for insuring natural catastrophe risk. The model estimated in the previous section showed that comparative advantage in risk bearing can explain the supply of terrorism reinsurance in Germany.

Does the relative cost of risk determine the demand for (corporate) terrorism insurance? In this section we empirically investigate this question using a dataset from the German government sponsored terrorism insurer. We first review how according to risk management theory, different factors might affect the demand for catastrophe insurance. We adjust the hypotheses to fit the institutional arrangement established in Germany, present our dataset and estimate a regression model.

MacMinn (1987) shows that corporate insurance can help to save expected *agency costs*. It is a necessary condition that the loading on the fair premium is smaller than the

[16] Wharton Risk Management and Decision Process Center (2005)

expected insolvency costs or the gains from controlling the agency problem. Froot (1999) observes substantial loadings on catastrophe reinsurance premiums. This leads us to conclude that *insolvency costs* and *agency costs* do not provide sufficient motivation to purchase catastrophe insurance. We do not expect *taxes* to motivate corporations to purchase insurance in Germany, since the corporate tax is linear.[17] However, another factor not yet mentioned in the literature, might play a more crucial role. The strict *labour market laws* and labour market imperfections in Germany provide incentives to purchase corporate insurance as labour market laws make it very costly to hire and dismiss employees. *Real services* cannot provide incentives to purchase terrorism insurance through Extremus as the company does not offer any service to its customers such as assessing terrorism risks or evaluating loss control measures.

There are other factors that can stimulate the propensity to purchase coverage from Extremus. The price for an insurance policy $P(\tilde{x})$ is in theory set to reflect the risk of the insured object and to include a loading ($P(\tilde{x}) = \alpha E(\tilde{x}) + \beta VAR(\tilde{x}) \mid \alpha \geq 1, \beta \geq 0$)). In contrast to this Extremus uses a one risk pricing structure for its policies, where the premium only depends on total insured value and maximum annual compensation. While the policyholder can choose the maximum annual compensation, the information on the total insured value is obtained from the corporation's fire policy. That is why we assume that it is not the cost of cash flow fluctuations determining the propensity to insure against terrorism. The "one risk class" pricing provides incentives for companies particularly prone to terrorist attacks to buy this insurance which are more prone to terrorist attacks.

As a result the policies offered are very attractive to high risk clients. Rothschild et al. (1976) have demonstrated that if insurers are unwilling or unable to calculate accurate premiums for different risks due to information asymmetries or regulation one will not receive a pooling equilibrium. In consequence of this the high risks create an externality to the low risks while at the same time they cannot profit from the arrangement.

We therefore investigate if the amount of terrorism insurance a policyholder of Extremus demands depends on its terrorism risk. We assume that the main aspects determining a corporation's terrorism risk is the production technology employed by the corporation, the location of the company's headquarters and the policyholder's visibility:

$$Degree\ of\ \ Coverage = F(size,\ production\ technology,\ location)$$

[17] We do not expect loss carry forwards to play an important role.

The price and quantity data we analyze are provided by Extremus. The data include information on all contracts for the years 2003 and 2004. The dataset consists of 1077 observations for 2003 and 1024 observations for 2004. A typical entry includes the name, the headquarters' address, the amounts insured under the standard fire policy, a classification of the sector the company operates in and the price of the policy. It also shows the selected maximum annual compensation (MAC), inception and expiration date of the policy.[18]

We measure the demand for terrorism insurance as the *level of coverage* (DoC) selected by the company which is the ratio of maximum annual compensation to the total insured value. Table 4 displays summary information on the level of coverage chosen by the policyholders of Extremus in 2003 and 2004. We see that a surprisingly high percentage, 66 % (2004: 61 %) of all policyholders, decides to buy full coverage.

Table 4: Degree of insurance (DoC) coverage of policyholders measured as ratio of maximum terrorism compensation to total insured value for the years 2003 and 2004

Moments			**Percentiles Smallest**		
	2003	**2004**		**2003**	**2004**
Mean	0.85	0.86	1%	0.05	0.07
Std. Dev.	0.27	0.25	5%	0.24	0.25
			10%	0.37	0.39
Variance	0.07	0.07	25%	0.73	0.91
Skewness	-1.54	-1.74	39%	1	1
Kurtosis	4.03	4.61	50%	1	1
N=	1077	1024	99%	1	1

To test our hypothesis that the level of coverage depends on the terrorism exposure of a policyholder we have defined the following proxy variables:

Size: A company's size affects the demand for terrorism insurance in two ways: On the one hand it increases the company's terrorism exposure as terrorists are likely to attack a larger (and therefore more visible) company. A larger corporation will therefore be more likely to purchase terrorism insurance. On the other hand, size also contributes to diversification. As a larger company is likely to be more diversified across lines of business and locations, the company's marginal willingness to pay for terrorism insurance will decrease as the total value insured increases.[19] Also the model estimated in the previous section provided evidence that the comparative advantage of risk bearing increases with the

[18] In order to control for sample selection bias we will match the data with company specific data from the Bureau van Dijk (Amadeus)-Database and estimate a Heckman model.

[19] This is also reflected in the report from Marsh McLennan, where the mean terrorism premiums per Dollar insured are decreasing as the total value insured increases. The numbers mentioned there state that the median terrorism premiums were 0.102‰ for total values insured of less than $ 100 millions, 0.058‰ for policyholders between $ 100 to 500 millions, 0.037‰ for total insured values between $ 500 million and 1 billion and 0.027‰ for larger total insured values. Marsh (2004), pg. 22.

corporation's size.[20] We measure *size* as total insured value (TIV) under the corporation's fire policy.

Sector and Regulation: There are several reasons why the sector may play a role in corporation's demand for terrorism insurance:

a) likelihood of attack will differ among sectors,
b) size of loss given a certain method of attack depends on sector's production technology,
c) probability of uninsured attack will also be correlated with the production technology,
d) possibility to pass the cost of terrorism insurance on to customers (elasticity),
e) compulsion.

Marsh (2004) shows that the mean prices per Dollar insured that are charged in the United States differ among sectors. The sectors Energy, Habitational and Real Estate pay on average between 0.1-0.12 ‰ for terrorism coverage. Construction, Financial Institutions, Transportation, Food and Beverages, Media, Utilities, Communications and Manufacturing purchase terrorism insurance for 0.04-0.06 ‰. Lower insurance premiums are paid by Public Entities, Retail, Healthcare and Education.

In order to capture sector specific effects we divide the clients of Extremus into 19 different sectors. Most of the policyholders are from the sectors Real Estate (2003: 398 contracts, 2004: 423), Insurance (2003: 174, 2004: 115), Banks and Asset Management (2003: 102, 2004: 122) and Real Estate Investment funds (2003: 81, 2004: 72). As a result of this discrimination we expect corporations in our data set belonging to the sectors Real Estate and Utilities (as in our Dataset Energy and Utility are grouped together) to purchase more and Churches, Foundations, Hospitals, Arts and Fairs, and Local Authorities to purchase less insurance than the average. We expect the other sectors (Construction, Financial Institutions, Transportation, Media, Telecommunication and Manufacturing) to display no sector specific effects.[21]

We report means and standard deviations of the policyholder's size by sectors in Table 5, columns 3 through 5.

[20] Cummins et al. (2004) show that policyholder purchasing excess of loss contracts will set the maximum compensation at less than the total insured value if loadings increase with size.

[21] Other aspects contributing to different patterns of demand for insurance against terrorism for different groups of policyholders are liability rules, legal requirements and the possibility to pass on the costs of insurance to customers or renters. All of these factors are likely to differ across different sectors. As a result of both influences we assume that the degrees of coverage will differ significantly between sectors.

Table 5 Size (total insured values) of Policyholders in € millions

	2003			2004		
Sector	**N**	**mean**	**Std. Dev.**	**N**	**mean**	**Std. Dev.**
Banks, Asset Management Co.	102	76.70	79.60	122	80.65	87.30
Construction	11	53.20	31.90	17	187.90	493.00
Utilities	17	6,830.00	16,400.00	14	1,402.00	4,780.00
Airports	26	634.00	1,340.00	22	672.50	1,290.00
Stores	32	1,000.00	3,650.00	26	512.20	1,460.00
Real Estate	398	80.90	138.00	423	78.26	125.00
Real Estate Investment Funds	81	63.70	48.00	72	64.44	47.90
Churches, Foundations	19	62.10	34.30	20	57.53	31.90
Hospitals	9	48.20	23.20	5	49.84	19.20
Art, Fairs	11	290.00	476.00	9	209.70	323.00
Logistics	10	59.70	34.30	8	68.95	35.40
Media, IT	30	2,740.00	14,300.00	27	2,908.00	14,400.00
Local Autorities	29	51.20	25.40	16	47.99	22.90
Tourism	25	106.00	160.00	30	108.00	146.00
Heavy Industry	24	5,720.00	16,400.00	23	6,818.00	16,400.00
Transportation	9	16,400.00	45,800.00	11	938.60	2,390.00
Insurance	174	259.00	2,270.00	115	351.40	2,790.00
Other	50	69.00	78.80	63	70.13	72.60
No Sector	20	80.80	77.80			
TOTAL	1077	592.00	5,980.00	1023	388.00	3,680

Regional Aspects: Terrorism causes large correlated damages. Looking at the attacks of September 11th 2001, we see that the attacks did not only cause the collapse of the North and South Tower of the World Trade Center, but also brought substantial damages to the buildings and business interruption losses to restaurants, offices, home owners and others surrounding the towers.[22] As the degree of correlation increases in densely populated areas, we assume that policyholders located in such areas are likely to choose higher levels of coverage if the premium is not set to reflect these factors. The numbers reported from Marsh (2004) support our hypothesis: The mean prices for terrorism coverage are higher in the densely populated north east of the United States. In the north east (south), the median price for terrorism insurance is 0.096 ‰ (0.057 ‰) of the total insured value. In the Western and Midwestern States the mean price for terrorism coverage is lower: 0.051 ‰ and 0.043 ‰ of the total insured value. These assumptions are in accordance with the experience of the successful Pool Re scheme in Great Britain, where the prices charged differ according to the location of an insured object.[23] To control for this aspect, we introduce a dummy for policyholders located in a city of more than 500,000 inhabitants.

In order to estimate the influence of *size* as well as *local* and *sector* on the demand for terrorism insurance we include those variables in our model. To avoid problems that result from heteroskedastity, we conduct our regression using a robust variance estimation. We

[22] An analysis of the damages caused by the attacks was conducted by Stempel (2002).
[23] Thomann (2003).

perform separate regressions for the years 2003 and 2004, and for all clients, and for the clients with total insured values with less than € 1.5 billon. We estimate the following model:

$$DoC = \beta_0 + \beta_1 Log(TIV_i) + \beta_2 (dens\_pop_i) + \sum_j \gamma_j Sector_i + \varepsilon$$

The F-Values of all four regressions are between 40 and 15 and imply that the models are highly significant. The adjusted R^2 values are between 0.28 and 0.38. The results are reported in Table 6.

Table 6: Influence of Size, Sector and Region (Robust OLS-Regression)

	REG A			**REG B**			**REG C**			**REG D**		
degree of coverage	**Coef**	**t**		**Coef**	**t**		**Coef**	**t**		**Coef**	**t**	
TIV	-0.12	-16.46	***	-0.12	-10.36	***	-0.13	-16.59	***	-0.12	-9.67	***
dens_pop	0.03	1.94	**	0.03	1.93	**	0.04	2.64	***	0.04	2.80	***
real_e_fund	0.16	5.84	***	0.16	5.82	***	0.15	5.79	***	0.15	5.85	***
real_est	0.14	5.39	***	0.14	5.43	***	0.13	5.38	***	0.13	5.44	***
construction	0.03	0.54		0.03	0.53		0.07	1.32		0.09	1.87	*
media	-0.02	-0.37		-0.02	-0.41		-0.07	-1.37		-0.08	-1.49	
local_auth	-0.12	-2.24	**	-0.12	-2.25	**	-0.17	-2.27	**	-0.16	-2.21	**
touri	-0.09	-1.16		-0.09	-1.15		-0.04	-0.77		-0.05	-0.80	
church	-0.04	-0.57		-0.04	-0.57		-0.08	-0.99		-0.07	-0.97	
hospital	-0.14	-1.33		-0.14	-1.33		0.16	5.14	***	0.16	5.32	***
art	-0.11	-1.30		-0.11	-1.13		-0.09	-0.88		-0.10	-0.90	
heavy_i	-0.06	-0.97		-0.07	-1.04		-0.03	-0.48		-0.04	-0.56	
transport	-0.03	-0.32		-0.03	-0.29		-0.05	-0.54		-0.01	-0.15	
insurance	0.03	1.12		0.03	1.17		0.02	0.56		0.02	0.57	
stores	-0.06	-1.22		-0.05	-0.90		-0.03	-0.59		-0.02	-0.33	
airport	-0.08	-1.35		-0.07	-1.25		-0.07	-1.11		-0.07	-0.95	
logistics	-0.21	-2.10	**	-0.21	-2.11	**	-0.25	-2.24	**	-0.25	-2.22	**
energy	-0.18	-2.19	**	-0.22	-2.29	**	-0.15	-1.51		-0.16	-1.50	
others	0.02	0.60		0.02	0.60		0.03	0.68		0.03	0.70	
none	0.14	3.34	***	0.14	3.35	***						
_cons	2.90	22.56	***	2.94	14.24	***	3.05	22.63	***	2.93	13.46	***
Number of obs	1077			1059			1023			1007		
F	40.43			18.33			34.25			15.31		
Prob > F	0			0			0			0		
R-squared	0.39			0.29			0.38			0.28		
Root MSE	0.21			0.21			0.21			0.21		

***: significant on a 1 % level, ** significant on 5 % level, * significant on 10 % level
REG A: 2003 all policyholders, REG B 2003 policyholders with TIV< € 1.5 bn, REG C: 2004 all policyholders, REG D 2003 policyholders with TIV< € 1.5 bn

Size: We find that consistent with our expectations, larger customers rely more on self insurance. The influence of the total insured value on the level of demand is negative (-0.12 for 2003 and 2004) and highly significant (t between -16 and -9.3). This means that a 1 %

increase in the total insured value will lead to an (absolute) reduction of the degree of coverage by 0,12 %. The implication is that larger terrorism claims are more efficiently borne by the corporation than by the insurance market.[24]

Location: We also find evidence that a company's location in a densely populated area leads to higher levels of coverage. The beta coefficients of the dummy variable *location in a city with more than 500,000 inhabitants* (dens_pop) are positive (0.03 for 2003 and 0.04 for 2004) and significant on the 10 % level in 2003 and the 5 % level in 2004. This supports the hypothesis that the presence of neighbours leads to a increased danger. Keohane et al. (2003) argue that the attractiveness of a target to a terrorist grows as the number of people exposed increases.[25]

Sector: In order to identify sectoral influences affecting demand, we insert dummy variables for the sectors Real Estate (real_est), Real Estate Investment Funds (real_e_fund), construction, media, local authorities (local_auth), tourism (touri), churches, hospitals, arts, manufacturing (heavy_i), transport, insurance, stores, airports, logistics, no Sector (none), and others (others). All four regressions show evidence of strong sectoral effects on the level of coverage chosen by the corporations. We use banks (N=102) as the reference group.[26] Our hypothesis states that certain sectors of the economy are more likely to be favoured by the pricing system while others are indifferent or discriminated against. We find some support for this thesis; Real Estate and Real Estate investment funds, which we expected to be favoured by the scheme, buy significantly more insurance (2003 Real Estate Investment Funds: +0.16, t=5.8, 2004: 0.15, t=5.8; 2003 Real Estate Companies +0.14, t=5.4; 2004: +0.13 t=5.4) than all other sectors.[27] Also in accordance with our expectations and the experience reported from the United States, local authorities (2003: -0.12, t=-2.24, 2004 -0.17 t=-2.2) and health care (2003 -0.14, t-1.33; 2004: -0.16, t=-5.1) buy less terrorism insurance. This implies that these groups are on average discriminated against.

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[24] This is not entirely unexpected as the anecdotal evidence reported by Doherty et al. (1993) points in a similar direction. He reports that the company British Petroleum self insures all large losses above $ 500 million. The reasons cited are the lack of competition in the market for large exposures and the fact that uninsured losses are tax deductible and thus leave a substantial amount with the taxpayers. Froot et al. (1997) provide evidence of capital market imperfections, which makes it hard for insurance companies to diversify large losses. These arguments are also supported by the arguments brought forward by Jaffee et al. (1997).

[25] These results contrast the pick-up rates reported by AON, where the pick-up-rates are highest (82 %) in the South of the United States and only 54 % in the North East.

[26] Banks are usually not owned by undiversified owners and according to our discussions are also not particularly discriminated against by the way Extremus determines its premiums.

[27] Yet we are surprised by the level of coverage demanded. As the minimum degree of coverage is .88%. This seems to provide evidence of either some kind of compulsion or of possibilities to pass the costs through to clients.

For our third model we match the data on terrorism risk insurance purchases provided from Extremus with financial data from Bureau van Dijk's Amadeus database. This allows us to estimate a full model on the demand for terrorism coverage. However, the low reporting standards for not-listed companies in Germany on the one hand and the complex ownership structure of the insured property on the other hand limit these efforts. In consequence we are only able to match 40 of the over 1000 insurance contracts of Extremus with the over 3800 non-financial corporations included in the Amadeus Database.[28] In order to control for selection bias we use a two-step estimation. The procedure goes back to Heckman (1979).

In a first step we estimate the influence of the company's size, the labour intensity of production, the liquidity ratio and if a company is stock listed on the probability to purchase coverage from Extremus. We hypothesize that the propensity to purchase this insurance depends on the terrorism risk exposure of the company. As stock listed (QUOTED) and larger companies, measured as the log of total assets (l_TOAS), have are more visible we expect them to have an increased demand for terrorism insurance. In accordance with standard risk management results we expect companies that have a lower liquidity ratio (LIQR) to have a higher probability to purchase terrorism insurance. In consequence of strict German labour laws limiting the possibilities of firms to reduce the number of workers in case of a large property claim we assume that companies with a higher labour intensity, measured as the ratio of the cost of employees to the operating revenue (SCT), have an increased probability to buy terrorism coverage. Table 7 presents the descriptive statistics of the full sample. Table 8 shows the summary statistics of the policyholders.

Table 7: Summary Statistics of Firm Data: Full Sample

Variable	Obs	Mean	Std. Dev.	Min	Max
l_TOAS	3831	17.93	1.66	9.95	25.95
SCT	3831	20.78	18.26	0	99.66
LIQR	3831	2.66	8.63	0	99.45
QUOTED	3831	0 .12	0.33	0	1

Table 8: Summary Statistics of Firm Data: Policyholders

Variable	Obs	Mean	Std. Dev.	Min	Max
DoC	40	0.44	0.36	0.0096	1
l_TOAS	43	20.18	3.68	9.95	25.55
SCT	43	21.34	16.44	0	64.06
LIQR	43	2.00	3.08	0	16.75

[28] We exclude insurance companies and banks due to the lack of comparability.

Table 9:Estimation of Sample Selection Equation

	Coefficient	z-Statistic
l_TOAS	0.287	7.91**
SCT	0.006	1.70
LIQR	-0.205	-0.96
QUOTED	0.233	1.45
Constant	-7.912	10.93**
Observations	3831	
Log likelihood	-174.67	

* significant at 5%; ** significant at 1%

In a second step we estimate the influence of the first three factors in the level of coverage. The dependent variable *degree of coverage* is measured as the ratio of maximum annual deductible to total insured value. The *degree of coverage* is a function of: the companies' total assets (l_TOAS), the labour intensity of production, (SCT), the liquidity ratio of the corporation (LIQR) and the inverse Mill's ratio.

Although larger corporations have a higher probability to purchase insurance, we hypothesize larger corporations to purchase lower levels of coverage. The influence of the other factors is assumed to be similar to the first step.

Table 10: Estimation of Terrorism Insurance Demand

Variable	A	B
l_TOAS	-0.084	-0.216
	(5.20)**	(1.29)
SCT	-0.009	-0.012
	(3.30)**	(2.54)*
LIQR	-0.035	-0.033
	(1.69)	(1.57)
Inverse Mills Ratio		-0,50
		(0.79)
Constant	2.456	6.354
	(6.83)**	(1.29)**
Observations	40	40

Absolute value of z statistics in parentheses * significant at 5%; ** significant at 1%

We display the results of the estimation in Table 10. Column A shows the results of ordinary least squares regression. Column B gives the result with the inverse Mill's ratio. Our model shows both that the size and a stock listing the probability of a company to purchase terrorism insurance. Consistent with our first model of insurance demand, were observe larger corporations demand a smaller level of coverage. In accordance with risk management theory we see that firms with a higher liquidity ratio insure less. Firms with labour intensive production functions have a higher probability to insure their risks with Extremus. At the

same time they purchase smaller amounts of coverage. The inverse Mill's ratio is negative yet not significant.

CONCLUSION

The purpose of this article was to consider two questions: what drives the supply of terrorism reinsurance and which factors determine the demand for terrorism insurance in Germany. Using two datasets from the German government sponsored terrorism insurer which had been matched with data on individual insurers and on policyholders we were able to gain insights on both questions. The results not only help to obtain a better understanding on how terrorism risk is allocated but they might also have some regulatory implications for the United States and Germany. Our main findings can be grouped into two parts.

On the supply side, where we observed a market outcome, we found evidence that the theory of costly risk bearing explains the amount of capacity insurers allocate for terrorism risk. Yet, in contrast to the research conducted by Kleffner et al. (1996) on earthquake risk we saw that the relative risk bearing capacity of individual insurers increases significantly with the insurer's size. At the same time, we observed a result unexpected in a reinsurance market resembling the one suggested by Borch (1962).[29] In a Borch (1962) market the relation between ceding risks to the reinsurance market and supplying reinsurance is indeterminate. In our model we witnessed a significantly lower supply of terrorism reinsurance by the insurers that are clients of Extremus. This outcome underscored that the transaction costs connected with the scheme surpass the benefits for the insurers from aggregation and diversification of unsystematic risk.

On the demand side, we observed what can be considered a standard result. In consequence of the uniform pricing scheme, we found strong evidence of adverse selection. Terrorism risk exposure determines the demand for terrorism insurance through Extremus. Since the company does not set its premiums according to terrorism exposure, coverage is only attractive for bad risks. While one would usually expect firms that have a comparative disadvantage in risk bearing to purchase more insurance, we cannot find any evidence for that. These results show that potential policyholders are not lexicographically risk averse to terrorism risk, but seem to have an idea of how (relatively) exposed they are to these risks.[30]

Some caveats remain. Our research only considered the German insurance market. As terrorism seems to be a bigger concern for the American insurance market one might observe

[29] In Germany insurers can cede risks to Extremus and reinsure a part of its portfolio.
[30] This contrasts the results of Fischhoff et al. (2003) and Johnson et al. (1993), which show that individuals perceive terrorism to be more dangerous than what is to be expected from statistics.

different behaviour. In order to obtain a clearer picture of the demand for terrorism insurance it would also be of interest to match more policyholder with financial data. Furthermore we could not answer the question why terrorism insurance is so popular with real estate corporations. Further research should examine how professional reinsurers handle terrorism risk and the role of alternative means to transfer terrorism risk to financial markets.

Our results might hold some policy implications for the United States. The theory on efficient risk bearing (Arrow (1964) and Borch (1962)) demands that all systematic risks are to be diversified while non-diversifiable risks should be allocated according to comparative advantage. Since our model shows that the (relative) risk bearing capabilities of smaller insurers are inferior they are on average discriminated by a deductible set to reflect a percentage of premium income. This means that the allocation of risk through TRIA is inefficient, because a proportional deductible does allocate risk according to comparative advantage. We therefore suggest that deductibles should be set to reflect corporate advantages for risk bearing.

The implications for Germany are more obvious. In order to increase market penetration it is necessary to set insurance premiums to reflect exposure.

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